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DATA BASE SPECIFICATIONS FOR THE
OPAQUE PROGRAM

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

A complete and current identification of the data and its format as used in the OPAQUE research program is presented.

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OPAQUE ---- A MEASUREMENT PROGRAM ON OPTICAL ATMOSPHERIC QUANTITIES IN EUROPE

PROGRAM PURPOSE AND OBJECTIVE

The ultimate objective for the research program is to develop a data base of atmospheric optical and infrared (IR) parameters which affect military systems. Until the present time, efforts to measure atmospheric optical parameters have been on a purely national basis. The time has now come to bring those efforts together and to consolidate the results, thus providing a more universally acceptable data base. Possible applications for the resulting data, would be in the optimization of optical or IR vision systems by taking due account of the influence of the atmosphere on the system capability. For example, one can immediately envisage the data being used in the optimization of Night Recon, Weapon Guidance and Laser Systems. The results from the measurement program would also be useful for specifying the atmospheric optical and IR (infrared) properties for operational (system deployment) purposes.

It will be possible to derive from the measured data, distribution of the frequency of occurrence for various parameters such as illumination levels, transmission, contrast reduction, as a function of geographical location, time, wave-length region, altitude, etc. Attempts are also being made to derive from the statistics, material relationships between the atmospheric optical parameters themselves as well as with the general meteorological condtions, which would be useful for prediction pruposes.

Electromagnetic radiation from the ultraviolet through the visible and infrared spectrum, is affected in its propagation through the earth's atmosphere by absorption and scattering from air molecules and aerosol or haze particles and by the refractive effects of atmospheric density changes. Therefore, any optical system whose function it is to look through the atmosphere is affected in its "seeing" capabilities by these atmospheric effects. Optical systems are being used in such military functions as

reconnaissance, target detection, recognition, and acquisition; also, in ranging and target designation, in weapons guidance and in optical cummincations, just to mention some examples. Optical systems use a wide range of wavelengths from the photopic response of the human eye through narrow and broadband systems in the visible and infrared (IR) and quasimonochromatic laser systems.

The spectral band width of such optical systems genrally has to be a compromise between the desire to keep it as narrow as possible for rejection of undesirable background, and the need to make it wider to be able to receive sufficient radiation energy on the detector. Active laser systems, on the other hand, have created now the possibility for extremely narrow path band systems.

Atmospheric optical properties affect systems in different ways. In all cases atmospheric extinction reduces the optical signal, originating from the object scene, along its path through the atmosphere to the receiver. This atmospheric extinction is due to the loss of light energy in the direct beam caused by molecular and aerosol absorption and also due to light scattered out of the direction of the beam by molecules and aerosols.

Some systems, such as reconnaissance systems or contrast seekers for weapons guidance, depend on the detection of brightness differences, or contrast, between object scene elements; for instance, a target and its surrounding background. The inherent contrast between two different elements in an object scene is reduced by the atmosphere because of light scattered along the path into the direction of the receiver. This scattered light is called air light or path radiance. If the intensity of path radiance becomes of the same magnitude as the radiance from the object scene, the contrast begins to disappear and different scene elements can no longer be distinguished.

Imaging systems, looking over very long paths, require very high angular resolution. In such systems, the resolution is also reduced by atmospheric turbulence and resulting optical scintillation phenomena along

the path. The picture becomes blurred and sharp edges become fuzzy.

Many optical military systems use active illumination systems, in particular lasers (for example, target designator systems, range finders). In these kinds of systems, one is concerned with the possibility that the laser beam might be detected from off-axis scattering by atmospheric aerosols and molecules.

Many studies have been conducted to determine the magnitude of these various atmospheric effects on military systems and operations. For example, in the employment of the F4/MAVERICK/EQ missile, cloud ceiling is a determining parameter for aircraft attack profiles; visibility affects the lock-on range for the target-background contrast sensor of the Maverick missile.

In another area, this data can be used to estimate the scattered light flux on an aircraft borne sensor originating from the scattering of a laser beam which is not directly hitting the aircraft.

The OPAQUE program is operating a number of stations covering the areas of Scandinavia, Central, Western and Southern Europe including some island or shipboard stations.

The choice for the location of these sites was based first on military tactical considerations; secondly on their representativeness with respect to the geographical environment and atmospheric meteorological conditions; and thirdly on availability of logistical support.

All data is being reduced to a commonly agreed upon data format compatible with computerized data analysis. All the data is to be reduced to an agreed format on a six monthly basis, and then collected in a central data bank from which the participating nations will be able to obtain consolidated dta tapes. Distribution of the consolidated data will be at an agreed classification level. Each member nation, or group of member nations

may then perform their own analysis. Published reports will then be submitted to a central secretary, to provide a common series of OPAQUE reports for distribution to the participating nations and to others as may be agreed jointly. It is also desirable that a six monthly review be made of the data analysis with the aim of avoiding unnecessary duplication.

PHYSICAL BACKGROUND

Every optical of IR system which is looking through the atmosphere, is affected by atmospheric light scattering, absorption, turbulence, atmospheric refraction, and nonlinear effects. The important parameters for any given line of sight for the atmospheric transmission, the atmospheric path radiance, and the turbulence factor.

These quantities are functions of the illumination conditions, the atmospheric properties themselves, and also the average terrain-background albedo. These factors affect the amount of radiation energy transmitted from a source along an atmospheric path to a receiver, the reduction of image contrast, and the distribution (spatial and temporal) of energy in the transmitted light beam.

For example, under homogeneous conditions the apparent luminance of target and background at range R can be written as

$$L_R = L_o e^{-\ \ R} + L_H(1 - e^{-\ \ R})$$

and

$$L'_R = L'_o e^{-\ \ R} + L_H(1 - e^{-\ \ R})$$

defining the contrast at zero range as

$$C_o = \frac{L_o - L'_o}{L_o + L'_o}$$

and the apparent contrast at range R as

$$C_R = \frac{L_R - L'_R}{L_R + L'_R}$$

it can be shown that

$$C_R = \frac{C_o}{1 + \frac{2L_H}{L_o + L'_o}\left(e^{+\sigma R} - 1\right)} \qquad (1)$$

Alternatively, using the diffuse reflectance of the target and background A and A', Eq. (1) can be written as

$$C_R = \frac{C_o}{1 + \frac{2\pi\Omega_o L_H}{(A + A')E_v}\left(e^{\sigma R} - 1\right)} \qquad (2)$$

The following definitions are relevant to the previous equations:

(1) C_o = Contrast at zero range

(2) L,L' = Luminance of target and background [Cd M^{-2}]

(3) T = Transmission = $e^{-\sigma R}$

(4) σ = Attenuation coefficient [M^{-1}]

(5) R = Range (m)

(6) E_v = Illuminance indident on a vertical plane [Lux]

(7) A,A' = Diffuse reflectance of target and background

(8) L_H = Horizon luminance [Cd M^{-2}]

(9) Ω_o = 1 sr

(10) Lp = Path Luminance (Cd M^{-2}) per range R

From a study of these parameters and Eqs. (1) and (2), it is possible to specify a minimum number of parameters which must be measured in any program before worthwhile results can be obtained. Section 3 gives what are considered to be the minimum set which it is worthwhile to measure, including IR transmission.

ϕ_o is the off-axis angle (0^o would be the direct beam). Such signals could be detected, and in response an aircraft could take appropriate counter-actions.

The effect of illumination levels on the ability of an observer to detect targets of various sizes has gained interest and lately with the development of image intensifier systems and Low Light Level Television (LLLTV). These systems have extended passive visual seeing from twilight down to nighttime illumination levels.

The aerosol scattering and absorption properties are described in the Mie theory. This theory applies to spherical particles and a few other simple particle configurations; however, comparisons with experimental results show good enough agreement to justify for most practical purposes the application of the Mie theory to natural aerosols. The scattering and absorption coefficients for aerosol particles between sizes r_1 and r_2 and distribution N(r) are

$$S_{\lambda a} = \int_{r_1}^{r_2} r^2 \pi \cdot Q_s \left(\frac{r}{\lambda}, m_\lambda\right) \cdot N(r)\, dr$$

and

$$k_{\lambda a} = \int_{r_1}^{r_2} r^2 \pi \, . \, Q_a \left(\frac{r}{\lambda} , m_\lambda \right) \, . \, N(r) \, dr$$

Q_s and Q_a are functions of the ratio of particle size to wavelength, and the aerosol particle refractive index m; they are derived from the Mie theory and are called efficiency factors for scattering and absorption, respectively. The refractive index of aerosol particles is a real number of completely transparent substances (no absorption); for absorbing substances it is a complex number,

$$m = n - in'$$

where n is the real part of the refractive index and n' the imaginary part. The quantity $4\pi n'/\lambda$ is the absorption coefficient of the aerosol substance; its dimension is $(cm)^{-1}$.

These equations define all the aerosol absorption and scattering quantities which are needed to calculate the transmission of a light beam through the atmosphere.

The Raleigh and Mie theory also give relationships for the intensity of radiation scattered out of a light beam into different directions. For molecular Rayleigh scattering, the angular scattering intensities are given by

$$I_\lambda (\varphi) = I_{\lambda,o} \quad \frac{3}{16\pi} \quad . \; S_{\lambda m} \, (1 + \cos^2 \varphi) \quad .$$

For spherical particles with sizes of the same order of magnitude or larger than the wavelength of the incident light, the Mie theory gives for the angular scattering intensitities

$$I_\lambda(\varphi) = I_{\lambda o} \cdot \frac{\lambda^2}{4\pi^2} \frac{i_1 + i_2}{2}$$

In order to predict the atmospheric optical/IR effects on the performance of a given optical system, two things are needed: (a) algorithms to calculate the specific quantity required for the physical condtions under which a system functions (for example, the transmittance for a specified spectral band and along a given atmospheric slant path), and (b) a description of the atmospheric properties which are required as input to (a) (for example the aerosol and molecular extinction coefficients as a function of wavelength, and the vertical profile of these parameters). The development of the algorithms is primarily a theoretical effort; the atmospheric properties must be derived from field measurements.

ATMOSPHERIC DATA BASIS

The basic atmospheric quantities which are needed to calculate atmospheric optical effects are: the distribution of atmospheric molecules and aerosols and their absorption and scattering properties, and the turbulance structure constant C_n[1] For most of these parameters, models describing their spatial distribution and in some cases temporal variations have been developed.

Models for the distribution of atmospheric molecular density, temperature and water vapor concentration are defined in the "Standard Atmospheres" and are based on long series of measurements. The data base for other minor gaseous components are less extensive. Laboratory and field measurements

exist of optical properties of the atmospheric molecular compnents, and have been compiled for optical calculations. Data on over 100,000 absorption lines from different molecular species have been compiled for wavelengths from the visible into the far infrared.

Whereas most of the molecular absorption is caused by two or three molecular species only (water vapor, carbon dioxide and ozone), the extinction due to atmospheric particulates or aerosol particles is much more complex. The concentration, size distribution, and composition of aerosols is extremely variable, spatially and in time; the development of representative models for the aerosol properties, therefore, is in a more preliminary state. Aerosol models have been developed for continental environments, such as rural or urban areas, and for maritime regions. These models describe also the variation of aerosol properties with altitude from the surface up to 100 km altitude. The vicissitude even within these models, however, makes their applicability to a given real world situation very difficult.

With the exception of those parameters, which are being collected routinely as part of the standard meterological observations (that is, temperature, humidity, surface visibility), the present data base for atmospheric optical modeling has no statistical significance. It describes only "general average" conditions.

ALGORITHMS FOR OPTICAL CALCULATIONS

Model calculations can be only as good as the input data for them. It can be stated at the outset, that in general the theoretical concepts and the algorithms for computing optical propagation characteristics are superior to the accuracy of the input data. This is certainly correct for transmission, emission, and single scattering computations, and even for most multiple scattering computations.

Algorithms for predicting scattering intensities are needed primarily for contrast reduction and sky radiance calculations. Path radiance P is composed of light which has been scattered several times along its path

through the atmosphere. Depending on how optically thick the atmosphere is, light which has been scattered up to ten times or more may contribute significantly to the radiation intensities of concern. No rigorous analytical solution has been presented as of this date for the radiation transfer problem involving multiple scattering in a real, aerosol-containing atmosphere.

NEED FOR EXTENDED ATMOSPHERIC OPTICAL DATA BASE

The military community is confronted with two different types of problems in predicting the atmospheric optical effects on the performance of a given optical system. The first one is associated with the question: "What is the probability that a given system will be able to function successfully in a certain environment?" This question is being asked by the systems designer to derive the appropriate systems specifications. It is also being asked by the systems analyst to develop the proper operational procedures and deployment plans for a system.

The second type of requirement is for a specific forecast for the atmospheric optical environment at the time and place of deployment of the system.

The first problem is one of developing an atmospheric optical climatology, and the second one requires a capability to forecase atmospheric optical conditions from the available standard meteorological observations and the general weather forecast. At present, however, one has in many cases only a qualitative understanding of the physical relationships between the meteorological factors and the environment on one side, and the atmospheric optical properties on the other. A quantitiative definition of these relationships requires also a reliable and comprehensive data base as a source for empirical correlations.

While such data are useful for system design planning, they must be used cautiously in operational planning. The data will be misused if employed to estimate the chances that a single or small number of missions

will find suitable conditions of cloud cover and surface visibility. If the data are used in relation to large number of missions, then more conficence can be attached to them.

These data can be of use to the operational weather forecaster, however, by providing him useful relationships for shaping his forecasts. Since the type of air mass is so important in influencing visibility and cloud cover, a refinement of the data by air mass type of synoptic situation would be even more useful to the forecaster.

ARRAY SPECIFICATION - DIRECT ACCESS FILE - DATA BASE SOFTWARE

TYPE: INTEGER

DIMENSION: 140

CONTENT BY WORD:

ARRAY WORD #	DATA	OPAQUE WORD #	FORMAT
1	Station No.	1	12
2	Date	2	16
3	Time	3	14
4	Duration of Meas. Cyc.	4	12
5	Comment Code 1	5	13
6	" " 2	6	13
7	" " 3	7	13
8	" " 4	8	13
9	" " 5	9	13
10	Scattering Value	10-1	11
11	Filter Value	10-2	11
12	Humidity Value	10-3	11
13	MRI Photopic, Beg. Val.	11	14
14	" " , Fin. Val.	12	14
15	" " , Max. Val.	13	14
16	" " , Min. Val.	14	14
17	" " , No. Meas.	15	13
18	Eltro Transmissometer, Beg. Val.	16	14
19	" " , Fin. Val.	17	14
20	" " , Max. Val.	18	14
21	" " , Min. Val.	19	14
22	" " , No. Meas.	20	13
23	Horizontal Luxmeter, Beg. Val.	21	14
24	" " , Fin. Val.	22	14
25	" " , Max. Val.	23	14
26	" " , Min. Val.	24	14
27	" " , No. Meas.	25	13
28	Vertical Luxmeter, North Value	26	14
29	" " , East Val.	27	14
30	" " , West Val.	28	14
31	" " , South Val.	29	14
32	Night Path Luminance, Beg. Val.	30	14
33	" " " , Fin. Val.	31	14
34	" " " , Max. Val.	32	14
35	" " " , Min. Val.	33	14
36	" " " , No. Meas.	34	13

ARRAY WORD #	DATA	OPAQUE WORD #	FORMAT
37	Variance Path Pct. Meter, Beg. Val.	35	14
38	" " " " , Fin. Val.	36	14
39	" " " " , Max. Val.	37	14
40	" " " " , Min. Val.	38	14
41	" " " " , No Meas.	39	13
42	" " " " , South Val.	40	14
43	" " " " , West Val.	41	14
44	" " " " , North Val.	42	14
45	Filtered Epplet Data, = .945	43	14
46	" " " , = .4	44	14
47	" " " , = .87	45	14
48	" " " , = 1.06	46	14
49	" " " , = .75	47	14
50	" " " , = .55	48	14
51	" " " , Photopic	49	14
52	" " " , + .3-3.51	50	14
53	" " " , Direct	51	14
54	" " " . = .3-3.52	52	14
55	Barnes Trans., 3-5	53	14
56	" " , 8-12	54	14
57	" " , 8-13	55	14
58	" " , Open or 4	56	14
59	" " , 3-5 Fin	57	14
60	Cloud Cover	68	11
61	Wind Dir. at 10^M	69	12
62	Wind Speed at 10^M	70	12
63	Wind Dir. at 2^M	71	12
64	Wind Speed at 2^M	72	12
65	Pressure	73	13
66	Temperature	74	13
67	Dew Point Temperature	75	13
68	Rain Rare	76	13
69	General Ground State	77	11
70	Total Rain Past Hour	85	13
71	Contel and Add. Meas. Code	64-1	11
72	Aerosol Ins. Code	58-1	11
73	Aerosol Date Code	58-2	11
74	Max. Channel Used	58-4	11
75	Aerosol Rel. Code	58-3	11
76	Add. Extinction Val.	64-3,4,5	13
77	Add. Extinction Val. Rel. Code	65-1	11
78	CO2 Concentration Val.	65-2,3,4	13
79	" " Rel. Code	65-5	11

ARRAY WORD #	DATA	OPAQUE WORD #	FORMAT
123	Barnes Transmissometer Qual.,55	84-1	11
124	" " " ,56	84-2	11
125	" " " ,57	84-3	11
126	" " " ,57	84-4	11
127	" " " ,59	84-5	11
128	Aerosol Channel 1 Data	58-5,59-1	12
129	" " 2 "	59-2,3	12
130	" " 3 "	59-4,5	12
131	" " 4 "	60-1,2	12
132	" " 5 "	60-3,4	12
133	" " 6 "	60-5,61-1	12
134	" " 7 "	61-2,3	12
135	" " 8 "	61-4,5	12
136	" " 9 "	62-1,2	12
137	" " 10 "	62-3,4	12
138	" " 11 "	62-5,63-1	12
139	" " 12 "	63-2,3	12
140	" " 13 "	63-4,5	12

A) The following terminology has been used in producing this document:

a) Data Bank - OPAQUE Random Access Disk Files.
b) Data Base - OPAQUE Data Managed by S2K DBMS.

B) Hyphenated data bank word numbers reflect digit positions within that word, with position "1" always the most significant digit.

C) All data base component names have been chosen to be Fortran compatible (length of name, default variable type) for ease of use with PLI software.

D) Data base component names follow one of two formats as follows:

a) Non-quality data
   i) Letter "I" (or "N" for "no. meas." data item) - indicating Fortran integer type variable.

   ii) Data item code - it should be noted that when partial data bank words are used, an attempt has been made, in general, to indicate this by including the digit positions in the component name.

b) Quality data
   i) Letter "I" - indicating Fortran integer type variable.

   ii) Letter "Q" - indicating quality data.

   iii) Data base component number - indicating which data quality figure is for.

E) Data bank word 64-2 (data item F-2) is not used and is set to zero in the data bank - this has no bearing on the OPAQUE data base.

DATA BANK RECORD NO.	DATA BANK COMPONENT NO.	DATA BASE COMPONENT NAME	DATA ITEM	DATA DESCRIPTION	PICTURE	DECODING ALGORITHM
	C1	ISTN	-	STATION NO.	9(2)	4
2	C2	IDATE	-	DATE	9(6)	YYMMDD
3	C3	ITIME	-	TIME	9(4)	HHMM
4	C4	IDUR	-	DURATION OF MEAS. CYC.	9(2)	MM
-	C5	ISTAT	-	UPDATE STATUS	9(1)	5
to 9	C11	ICOMNT	-	COMMENT CODE	9(3)	6
10-1	C21	ISCAT	-	SCATTERING	9(1)	7
10-2	C22	IFILT	-	FILTER	9(1)	8
10-3	C23	IHUM	-	HUMIDITY	9(1)	9
11	C101	ISSBEG	$S_S BEG$	MRI PHOTPIC, BEG. VAL.	9(4)	1
12	C102	ISSFIN	$S_S FIN$	" " , FIN. VAL.	9(4)	1
13	C103	ISSMAX	$S_S MAX$	" " , MAX. VAL.	9(4)	1
14	C104	ISSMIN	$S_S MIN$	" " , MIN. VAL.	9(4)	1
15	C105	NVSS	N_V	" " , NO. MEAS.	9(3)	--
16	C201	IEGBEG	$E_G BEG$	ELTRO TRANSMISSOMETER, BEG. VAL.	9(4)	1
17	C202	IEGFIN	$E_G FIN$	" " , FIN. VAL.	9(4)	1
18	C203	IEGMAX	$E_G MAX$	" " , MAX. VAL.	9(4)	1
19	C204	IEGMIN	$E_G MIN$	" " , MIN. VAL.	9(4)	1
20	C205	NVEG	N_V	" " , NO. MEAS.	9(3)	--
21	C301	IELBEG	$E_L BEG$	HORIZONTAL LUXMETER, BEG. VAL.	9(4)	1
22	C302	IELFIN	$E_L FIN$	" " , FIN. VAL.	9(4)	1
23	C303	IELMAX	$E_L MAX$	" " , MAX. VAL.	9(4)	1
24	C304	IELMIN	$E_L MIN$	" " , MIN. VAL.	9(4)	1
25	C305	NVEL	N_V	" " , NO. MEAS.	9(3)	--

DATA BANK RECORD NO.	DATA BASE COMPONENT NO.	DATA BASE COMPONENT NAME	DATA ITEM	DATA DESCRIPTION	PICTURE	DECODING ALGORITHM
26	C401	IEVN	E_V^N(north)	VERTICAL LUXMETER, NORTH VAL.	9(4)	1
27	C402	IEVE	E_V^E(east)	" " EAST VAL.	9(4)	1
28	C403	IEVS	E_V^S(south)	" " SOUTH VAL.	9(4)	1
29	C404	IEVW	E_V^W(west)	" " WEST VAL.	9(4)	1
30	C501	ILPBEG	L_P^{NT} BEG	NIGHT PATH LUMINANCE, BEG. VAL.	9(4)	2
31	C502	ILPFIN	L_P^{NT} FIN	" " " , FIN. VAL.	9(4)	2
32	C503	ILPMAX	L_P^{NT} MAX	" " " , MAX. VAL.	9(4)	2
33	CZ04	ILPMIN	L_P^{NT} MIN	" " " , MIN. VAL.	9(4)	2
34	C505	NVLP	N_V	" " " , NO. MEAS.	9(3)	--
35	C601	IFPBEG	F_P^E BEG	VARIABLE PATH PCT.METER, BEG.VAL	9(4)	2
36	C602	IFPFIN	F_P^E FIN	" " " " , FIN. "	9(4)	2
37	C603	IFPMAX	F_P^E MAX	" " " " , MAX. "	9(4)	2
38	C604	IFPMIN	F_P^E MIN	" " " " , MIN. "	9(4)	2
39	C605	NVFP	N_V	" " " " ,NO.MEAS.	9(3)	--
40	C606	IFPS	F_P^S	" " " "SOUTH VAL.	9(4)	2
41	C607	IFPW	F_P^W	" " " "WEST VAL.	9(4)	2
42	C608	IFPN	F_P^N	" " " "NORTH VAL.	9(4)	2

DATA BANK RECORD NO.	DATA BASE COMPONENT NO.	DATA BASE COMPONENT NAME	DATA ITEM	DATA DESCRIPTION	PICTURE	DECODING ALGORITHM
43	C701	IE01	E_0^1	FILTERED EPPLEY DATA, λ = .946	9(4)	1
44	C702	IE02	E_0^2	" " " λ = .4	9(4)	1
45	C703	IE03	E_0^3	" " " λ = .87	9(4)	1
46	C704	IE04	E_0^4	" " " λ =1.06	9(4)	1
47	C705	IE05	E_0^5	" " " λ = .75	9(4)	1
48	C706	IE06	E_0^6	" " " λ = .55	9(4)	1
49	C707	IE07	E_0^7	" " " PHOTOPIC	9(4)	1
50	C708	IE08	E_0^8	" " " λ = .3to3.5	9(4)	1
51	C709	IE09	E_0^9	" " " DIRECT	9(4)	1
52	C710	IE10	E_0^{10}	" " " λ = .3to3.5	9(4)	1
53	C801	IT1	T_1	BARNES TRANSMISSOMETER, 3-5μ BEG	9(4)	1
54	C802	IT2	T_2	" " 8-12 μ	9(4)	1
55	C803	IT3	T_3	" " 8-13 μ	9(4)	1
56	C804	ITX	T_x	" " OPEN OR 4μ	9(4)	1
57	C805	IT8	T_8	" " 3-5μ FIN	9(4)	1
58-1	C1001	IX1	X	AEROSOL INSTRUMENT CODE	9(1)	10
58-2	C1002	IX2	X	AEROSOL DATA CODE	9(1)	11
58-3	C1004	IX3	X	AEROSOL RELIABILITY CODE	9(1)	22
58-4	C1003	IX4	X	MAX. CHANNEL USED	9(1)	12

DATA BANK RECORD NO.	DATA BASE COMPONENT NO.	DATA BASE COMPONENT NAME	DATA ITEM	DATA DESCRIPTION	PICTURE	DECODING ALGORITHM
58-5,59-1	C1101	IX5A1	X,A	AEROSOL DATA, CHANNEL 1	9(2)	13
59-2,3	C1102	IA23	A	" " " 2	9(2)	13
59-4,5	C1103	IA45	A	" " " 3	9(2)	13
60-1,2	C1104	IB12	B	" " " 4	9(2)	13
60-3,4	C1105	IB34	B	" " " 5	9(2)	13
60-5,61-1	C1106	IB5C1	B,C	" " " 6	9(2)	13
61-2,3	C1107	IC23	C	" " " 7	9(2)	13
61-4,5	C1108	IC45	C	" " " 8	9(2)	13
62-1,2	C1109	ID12	D	" " " 9	9(2)	13
62-2,3	C1110	ID23	D	" " " 10	9(2)	13
62-5,63-1	C1111	ID4E1	D,E	" " " 11	9(2)	13
63-2,3	C1112	IE23	E	" " " 12	9(2)	13
63-4,5	C1113	IE45	E	" " " 13	9(2)	13
64-1	C31	IFI	F	CONTEL & ADD. MEAS. CODE	9(1)	14
64-3,4,5	C41	IF345	F	ADD. EXTINCTION VALUE	9(3)	?
65-1	C42	IGI	G	ADD. EXTINCTION RELIABILITY	9(1)	?
65-2,3,4	C51	IG234	G	CO_2 CONCENTRATION VALUE	9(3)	?
65-5	C52	IG5	G	CO_2 CONCENTRATION RELIABILITY	9(1)	?
66-1,2,3	C61	IH123	H	LASER TURBULENCE VALUE	9(3)	?

DATA BANK RECORD NO.	DATA BASE COMPONENT NO.	DATA BASE COMPONENT NAME	DATA ITEM	DATA DESCRIPTION	PICTURE	DECODING ALGORITHM
66-4	C62	IH4	H	LASER TURBULENCE RELIABILITY	9(1)	?
66-6,67-1	C71	IH511	H,I	BARNES INDICATOR VALUE -1	9(2)	?
67-2	C72	II2	I	" " RELIABILITY -1	9(1)	?
67-3,4	C81	II34	I	" " VALUE -2	9(2)	?
67-5	C82	II5	I	" " RELIABILITY -2	9(1)	?
68	C901	IN	N	CLOUD COVER	9(1)	15
69	C902	IDD	DD	WIND DIRECTION AT 10 M	9(2)	16
70	C903	IFF	FF	WIND SPEED AT 10 M	9(2)	17
71	C904	ID2D2	D_2D_2	WIND DIRECTION AT 2 M	9(2)	16
72	C905	IF2F2	F_2F_2	WIND SPEED AT 2 M	9(2)	17
73	C906	IPPP	PPP	PRESSURE	9(3)	18
74	C907	ITTT	TTT	TEMPERATURE	9(3)	19
75	C908	ITDTD	$T_DT_DT_D$	DEW POINT TEMPERATURE	9(3)	19
75	C908	ITDTD	$H_RH_RH_R$	RELATIVE HUMIDITY	9(3)	20
76	C909	IRRATE	RRR-1	RAIN RATE	9(3)	21
77	C910	IE	E	GENERAL GROUND STATE	9(1)	3
78-1	C2101	IQ101	Q	MRI PHOTOPIC QUALITY, 11	9(1)	22
78-2	C2102	IQ102	Q	" " " 12	9(1)	22
78-3	C2103	IQ103	Q	" " " 13	9(1)	22
78-4	C2104	IQ104	Q	" " " 14	9(1)	22

DATA BANK RECORD NO.	DATA BASE COMPONENT NO.	DATA BASE COMPONENT NAME	DATA ITEM	DATA DESCRIPTION	PICTURE	DECODING ALGORITHM
79-1	C2201	IQ201	Q	ELTRO TRANSMISSOMETER QUALITY	16 9(1)	22
79-2	C2202	IQ202	Q	" " "	17 9(1)	22
79-3	C2203	IQ203	Q	" " "	18 9(1)	22
79-4	C2204	IQ204	Q	" " "	19 9(1)	22
80-1	C2301	IQ301	Q	HORIZONTAL LUXMETER QUALITY	21 9(1)	22
80-2	C2302	IQ302	Q	" " "	22 9(1)	22
80-3	C2303	IQ303	Q	" " "	23 9(1)	22
80-4	C2304	IQ304	Q	" " "	24 9(1)	22
80-5	C2401	IQ401	Q	VERTICAL LUXMETER QUALITY	26 9(1)	22
80-6	C2402	IQ402	Q	" " "	27 9(1)	22
80-7	C2403	IQ403	Q	" " "	28 9(1)	22
80-8	C2404	IQ404	Q	" " "	29 9(1)	22
81-1	C2501	IQ501	Q	NIGHT PATH LUMINENCE QUALITY	30 9(1)	22
81-2	C2502	IQ502	Q	" " " "	31 9(1)	22
81-3	C2503	IQ503	Q	" " " "	32 9(1)	22
81-4	C2504	IQ504	Q	" " " "	33 9(1)	22
82-1	C2601	IQ601	Q	VARIABLE PATH FCT. METER QUALITY	35 9(1)	22
82-2	C2602	IQ602	Q	" " " " "	36 9(1)	22
82-3	C2603	IQ603	Q	" " " " "	37 9(1)	22

DATA BANK RECORD NO.	DATA BASE COMPONENT NO.	DATA BASE COMPONENT NAME	DATA ITEM	DATA DESCRIPTION		PICTURE	DECODING ALGORITHM
82-4	C2604	IQ604	Q	VARIABLE PATH FCT. METER QUALITY	38	9(1)	22
82-5	C2605	IQ605	Q	" " " " "	40	9(1)	22
82-6	C2606	IQ606	Q	" " " " "	41	9(1)	22
82-7	C2607	IQ607	Q	" " " " "	42	9(1)	22
83-1	C2701	IQ701	Q	FILTERED EPPLEY DATA QUALITY	43	9(1)	22
83-2	C2702	IQ702	Q	" " " "	44	9(1)	22
83-3	C2703	IQ703	Q	" " " "	45	9(1)	22
83-4	C2704	IQ704	Q	" " " "	46	9(1)	22
83-5	C2705	IQ705	Q	" " " "	47	9(1)	22
83-6	C2706	IQ706	Q	" " " "	48	9(1)	22
83-7	C2707	IQ707	Q	" " " "	49	9(1)	22
83-8	C2708	IQ708	Q	" " " "	50	9(1)	22
83-9	C2709	IQ709	Q	" " " "	51	9(1)	22
83-10	C2710	IQ710	Q	" " " "	52	9(1)	22
84-1	C2801	IQ801	Q	BARNES TRANSMISSOMETER QUALITY	53	9(1)	22
84-2	C2802	IQ802	Q	" " "	54	9(1)	22
84-3	C2803	IQ803	Q	" " "	55	9(1)	22
84-4	C2804	IQ804	Q	" " "	56	9(1)	22
84-5	C2805	IQ805	Q	" " "	57	9(1)	22

FOOTNOTES:

1) $I_1I_2I_3I_4$ = Float $(I_1I_2I_3))$ * (10. ** Float $(I_4$ + 6))

2) $I_1I_2I_3I_4$ = Float $(I_1I_2I_3))$ * (10. ** Float $(I_4$ + 8))

3) See Appendix 1 for codes and their significance.

4) I_1I_2 = a) I_1 = Station location code (see appendix 2)

b) I_2 = Issue level of tape

i) $1 \leq I_2 \leq 4$ = Preliminary data

ii) $5 \leq I_2 \leq 9$ = Reviewed data

5) See Appendix 3 for code

6) See Appendix 4 for code

7) Scattering Code: = 1 - Denotes scattering being presented

= 2 - Denotes extinction being presented

= 3 - Denotes both being presented

8) Filter Code: = 4 - 3.4 - 5.5 m

= 5 - Open (2-14 m)

= 6 - 4 calibration filter

= 7 - To be decided

9) Humidity Code: = 1 - Denotes direct humidity value to .1%

10) See Appendix 4 for code

11) See Appendix 5 for code

12) Maximum Channel: = 0 - No data

= (Max. channel - 4) - Data available (N.B. - data is present, at least 5 channels are used).

13) I_1I_2 Float (I_1I_2) (See Appendix 7 for further information)

14) See Appendix 7 for code

15) $I_1 \leq 8 \rightarrow .125$ * Float (I_1) ; $I_1 = 9$ No measurement

16) I_1I_2 Integer value indicating the nearest 10° value from true North as follows:

-5° to $5^\circ \rightarrow 36$

5° to $15^\circ \rightarrow 01$

.

.

.

.

345° to $355^\circ \rightarrow 35$

Special values: $I_1I_2 = 00$ Calm

$= 99$ No observation or failure

17) I_1I_2 Integer value indicating wind speed in M/sec.
Special value: $I_1I_2 = 99$ No observation or failure.

18) $I_1I_2I_3$ Integer value of pressure in MBAR.
e.g. $I_1I_2I_3 = 024$ 1024 MBAR
$I_1I_2I_3 = 973$ .973 MBAR
(N.B. Pressure range is approximately 950-1050)

19) $I_1I_2I_3$ $I_1I_2I_3 < 500$ 0.1 * Float $(I_1I_2I_3)$

$I_1I_2I_3 > 500$ -0.1 * Float $(I_1I_2I_3 - 500)$

$I_1I_2I_3$ 999 Failure code

20) $I_1I_2I_3$ 0.1 * Float $(I_1I_2I_3)$

21) $I_1I_2I_3$ 0.1 * Float $(I_1I_2I_3)$

Mean rain rate value in MM/HR. The recommended sampling period is 4 minutes. Alternative periods must be noted in the comments.

Special value: $I_1I_2I_3 = 999$ Failure code

22) See Appendix 8 for codes

23) $I_1I_2I_3$ Total rain in the past hr. in MM
Special value: $I_1I_2I_3 = 999$ No observation or failure.

APPENDIX 1 - GROUND STATE CODES

0 = Dry

1 = Wet

2 = Flooded

3 = Frozen

4 = Snow patches

5 = Snow cover or hail cover

6 = Ice or frozen snow cover

7 = Melting snow

8 = Situation outside OPAQUE scheme; see comment list

9 = No observation

APPENDIX 2 - STATION CODES

1 = Canada/Denmark

2 = France

3 = Germany

4 = Italy

5 = Netherlands

6 = UK

7 = USA/Germany

APPENDIX 3 - UPDATE STATUS

NOTE - This item does not appear in the original OPAQUE data bank, but has been included in the data base for convenience. It is meant to serve as an indicator of the status of any given logical entry (hour) in the data base. The following convention will be used:

0 = Raw data from random access data file
1 =
2 =
3 =
4 =
5 =
6 =
7 =
8 =
9 =

APPENDIX 4 - AEROSOL INSTRUMENT CODE

0 = No data collected
1 = Active probe (A)
2 = Classical probe (C)
3 = (A) and (C)
4 = Royco (R)
5 = (A) and (R)
6 = (C) and (R)
7 = (A) and (C) and (R)
8 = Other - see comments

APPENDIX 5 - AEROSOL DATA CODE

0 = Data not reviewed for features
1 = Reasonable approximation
2 = Statistically unreliable
3 = Statistically unreliable at larger sizes - low counts
4 = Single peak distribution
5 = Multiple peak exists

APPENDIX 6 - AEROSOL DATA DERIVATION

The two digits of stored aerosol data are determined by the algorithm:

$$I_1 I_2 = \text{IFIX}(10.*(\log(\frac{d}{d \log \delta}(N)) + 4))$$

where the following constraint applies:

$$0 \leq (\log(\frac{d}{d \log \delta}(N) + 4) \leq 100$$

and where: δ = Particle diameter

N = Particle count/BIN

In 13 channels as indicated below:

0.200	-	0.283
0.283	-	0.400
0.400	-	0.566
0.566	-	0.800
0.800	-	1.131
1.131	-	1.600
1.600	-	2.263
2.263	-	3.200
3.200	-	4.525
4.525	-	6.400
6.400	-	9.051
9.051	-	12.800
12.800	-	18.100

APPENDIX 7 - CONTEL AND ADDITIONAL MEASUREMENT CODE

0 = No measurement

1 = Contel

2 = Sky camera

3 = Contel and sky camera

4 = Additional measurements only as in comments

5 = Contel and additional measurements

6 = Sky camera and additional measurements

7 = Contel and sky camera and additional measurements.

APPENDIX 8 - RELIABILITY CODES

First group, no data available

0 No measurement, as the instrument is not (yet) working (min. period a week, for shorter time use 1).

1 No measurement in this measurement series or may be in the neighboring series (max. some weeks, for longer time use 0)
or
signal outside the range covered by the instrument or signal destroyed by other influence (e.g. by looking direct in the direction of the sun).

Second group, the relative error of the data is below 50% (Barnes 15% abs.), i.e. not good for relationships but useful for statistics.

2 Quality below normal standards is assumed, as the data has not been checked.

3 Quality below normal standard, caused by measurement circumstances (as sun facing the instrument or fluctuating light) or known by detailed knowledge of the specific instrument (e.g. noise at low signal levels), or proven by bad calibration results.

Third group, the relative error of the data is below 15% (Barnes 5% abs.), i.e. useful for all normal purposes. All data are checked for bad circumstances as e.g. sun problems.

4 Quality normal, assumed by detailed knowledge, even though it is some time since calibrations have been performed or proven by frequent, agreeing calibrations.

Fourth group, the relative error of the data is below 5% (Barnes 2% abs.), i.e. they are especially useful for demanding functional correlation relationships.

5 Quality above normal standard, based on knowledge of instrumental performance and information contained in the basic data set (e.g. absence of veiling glare in the path luminence meters from sun close to optical axis, as derived from the sun position and a threshold angle equivalent to a 5% effect with respect to effects of artificial light sources (see 6).

6 Quality above normal standard, as 5, but also supported, for specific interpretations, by information in addition to that contained within the basic data set:

a) in case of Epply measurements: without any clouds obscuring the sun,

b) in case of Barnes measurements: during rain whether indicated or not by rain rate meters,

c) in case of extinction coefficient measurements: with values at homogeneous conditions,

d) in case of path luminance during night: without any occasional artificial light sources affecting the measurement.

DAT
FILM
10-